Space Weather Technical Forecast

Issued on Friday, 09 February 2024 at 12:36 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: R1-R2 Radio Blackouts Likely. Slight Chance G1 to start and end period. Ongoing daily Slight Chance of S1.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity recorded at GOES16 has been Moderate over the past 24 hours, with several M-class flares observed, the peak of which was a long-period M3.9 at 08/2355UTC from Ex-AR3575, which now lies narrowly over the western limb.

There are now seven surviving sunspot regions on the disc as Ex-AR3575 and Ex-AR3564 have passed over the western limb, while AR3577 and AR3578 have faded to plage.

AR3576 is now utterly dominant in terms of area and magnetic complexity, with its Fkc/BGD maintained, with its span up to 18 degrees. There was some consolidation evident in recent hours in its peripheral small spots, leading to a slight reduction in overall penumbral area, however the main Mt Wilson Delta in its centre intensified. Thus far this region has produced a mixture of impulsive and long-period flare characteristics. Of potential note is a faint filament that appears to be anchored at its northern end near the Mt Wilson delta within AR3576 - this arrangement may yet prove unstable and is an aspect of monitoring.

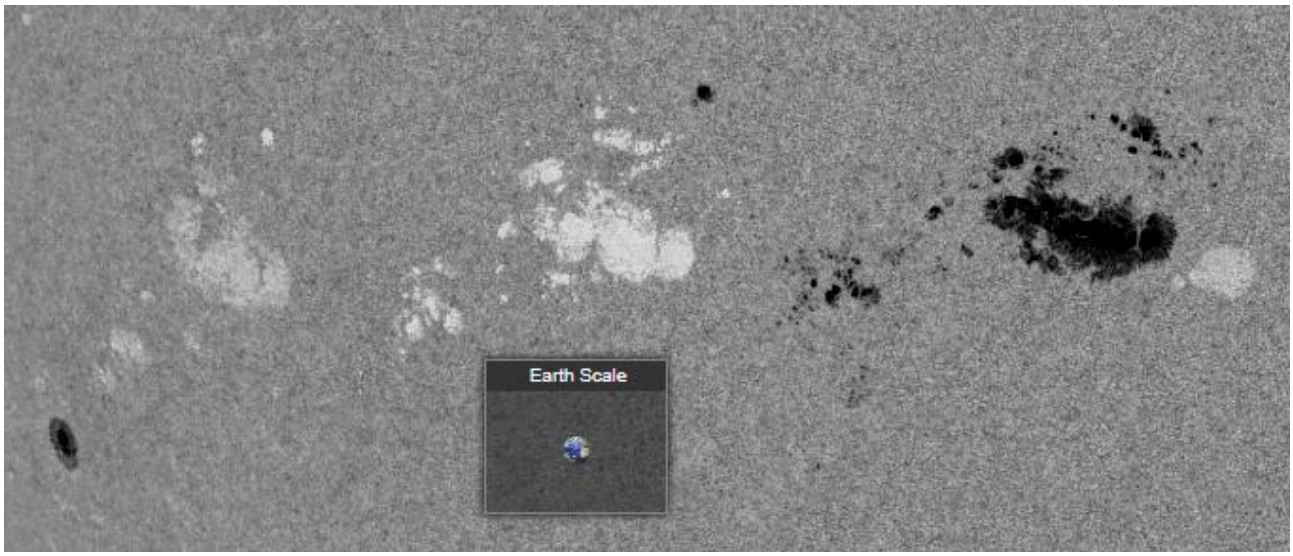

Figure 0: Helioviewer.org-derived HMIIF diffrence imagery of the footprint of AR3576 at 06/1200UTC, 08/0000UTC and 09/1200UTC (i.e. at 36-hour intervals). Earth is shown inset for scale – the sunspot exceeds 1000mhs at present.

There were filament eruptions observed in the period - firstly one from south-centre disc at 08/2030UTC. This appeared to remain anchored longest at its eastern end to perhaps deflect it

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more eastward than would be expected from its location on the facing side. This event has been tentatively associated with a Coronal Mass Ejection (CME) seen heading in part slightly east of the Sun-Earth line, overlaid in terms of coronagraphs' FoV over an earlier CME from behind the eastern limb. Confidence in this attribution is therefore low overall, however MOSWOC Enlil modelling suggests this CME crosses 1AU around 12/1200UTC. The deterministic run falls fairly centrally in the MOSWOC Enlil ensemble solutions, however some of the earlier arrivals are less favoured given an erroneous intervening fast wind in MOSWOC Enlil model-space (a slow regime is instead more likely between now and the new UTC working week).

A second possible filament eruption occurred in the northeast disc at 08/2300UTC, visible in AIA304, however there was no definitive ejecta seen on coronagraphs. Other CME-generated events were largely associated with the off-going southwestern limb regions of Ex-AR3575, Ex-AR3564, with no Earth effects anticipated, although modelling is still being carried out to confirm this.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by ACE and DSCOVR at L1, were Slightly Elevated, with speeds near 450km/s with a roughly level trend. This is possibly the tail end of CH96, although the feature itself is now no longer visible over the western limb. This mainly stable tendency applied to most solar wind characteristics, with density near background in single-figures ppcc and IMF smooth at or below 6nT, with the north-south component showing slow variation between -4 and +5nT. The mainly positive phi angle (away from the Sun) changed to negative briefly around mid-UTC evening and mid-UTC morning.

The net result of the above solar wind measures was provisionally Quiet Kp indices throughout.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux remained at Background levels.

GOES16 high energy (greater than 2MeV) electron flux remained at Normal Background levels. The associated 24-hour fluence was well below the Active (1e8 integrated pfu) threshold and has had a flat trend, with a 09/0001UTC fluence value of 1.04e6pfu observed.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate X-ray flare activity remains Likely, and X-class activity a Slight Chance, with a slight reduction in the daily risks of both with the passing of Ex-AR3575 before the UTC weekend. The contributions from a suite of arriving eastern limb regions has yet to be determined, pending their presentation for analysis.

Solar Wind / Geomagnetic Activity: Up to two glancing incidence CMEs may feature in the period: firstly from the M4.2 on 06 February which may bring a Slight Chance of G1 inside the coming 24 hours, and then a second event from the 08/2030UTC filament eruption, that may round out the forecast period with a Slight Chance of G1 later in the UTC day of Monday 12 February. No fast wind regimes are otherwise expected, and the forecast may be Quiet throughout should both CMEs not affect Earth.

Energetic Particles / Solar Radiation: High energy proton flux has the potential to rise in response to any significant flares, most likely from Ex-AR3575 or, increasingly, AR3576. Because the component from the first reduces as the latter increases, the risk is a roughly stable Slight Chance on all days of the period.

High energy electron flux (greater than 2MeV) is expected to continue at current Normal Background levels, with the associated 24-hour electron fluence remaining well below the Active threshold.

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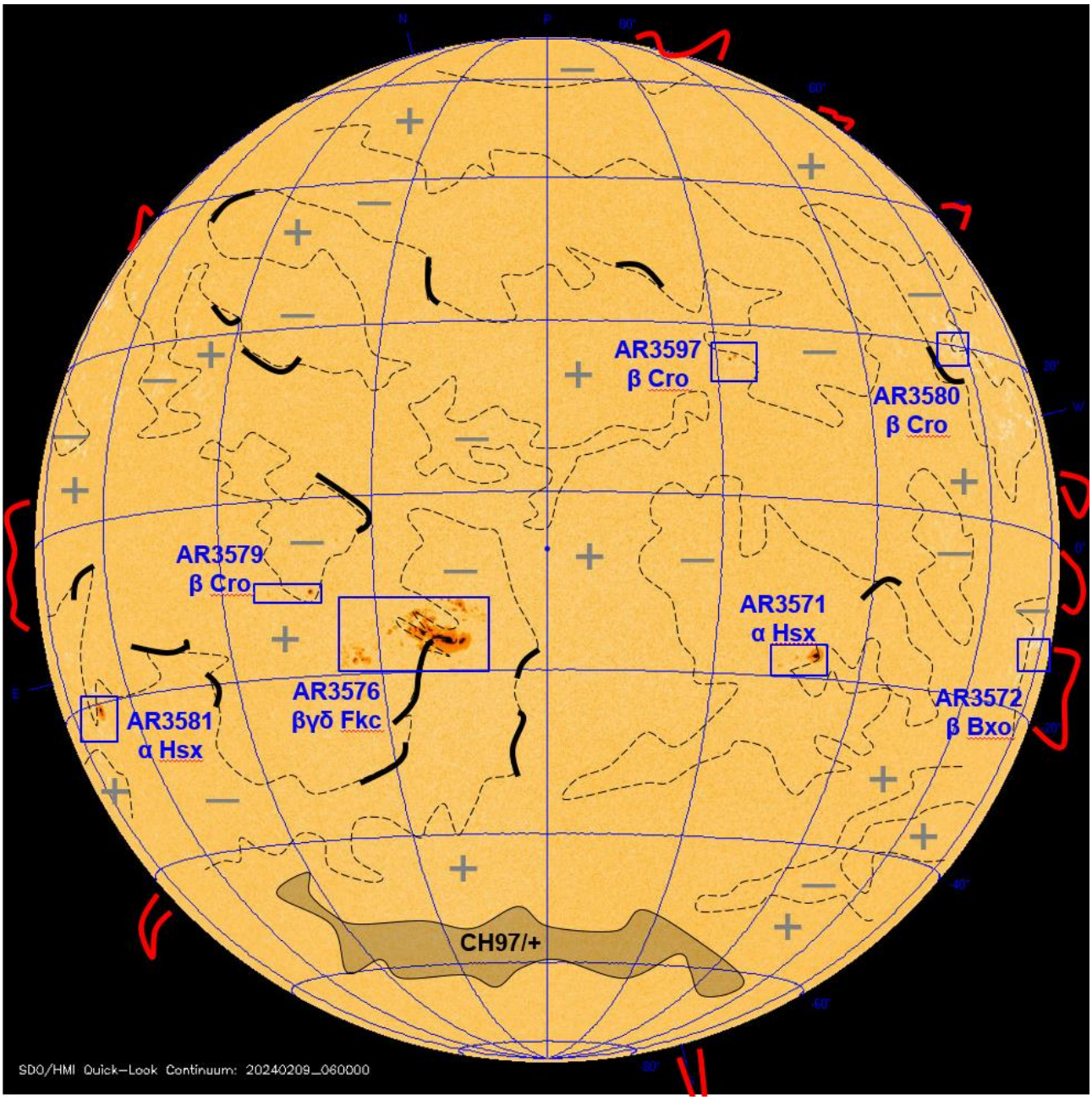
Figure 1. Solar Analysis Valid 09/0600UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The current Slightly Elevated solar wind is perhaps most likely derived from CH96. The fast wind should now shortly wane as the feature responsible is now no longer visible, perhaps already evidenced by the more intermittent positive phi angle. The only other coronal hole present on the disc, CH97, lies at low solar latitude and noteworthy impacts are not expected.

A CME that left the Sun in association with the M4.2 flare early on 06 Feb may give a glancing blow late today (Friday 09 February) or early day 2, bringing a Slight chance of a G1/Minor Geomagnetic Storm interval, however a miss is more probable. In addition to this possible glance, analysis of the 08/2030UTC south-centre filament eruption now carries a similar Slight Chance of G1 at the end of the four day period. This feature is modelled as crossing 1AU, mainly behind and below the Sun-Earth line around 12/1200UTC, however the presence in MOSWOC Enlil of a minor but erroneous 400km/s fast wind in the intervening period means that some of the earlier ensemble members are discounted, with arrival more probable on or after 12/1200UTC. Given the slow transit time, geomagnetic effects will probably be largely contained within the same UTC day, with any later arrival suitably less impactful.

There are Slight Chances of G1 to start and end the four-day period, with otherwise Quiet conditions perhaps persisting throughout should both inbound CMEs miss. The UTC day of Sunday 11 February is perhaps the most reliably Quiet of the period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	10	1	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
06/0708	Partial	AR3575 M4.2	SW	819km/s	Overnight UTC days 09 into 10 February	Slight glance
08/2030	Partial	Filament eruption	S centre	641	12/1200UTC or later in UTC day	Glancing blow

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Figure 2: Latest MOSWOC Enlil (badge time 09/0600UTC), showing the 06 February CME as a slight glance in the next 24 hours and a slightly miore assured glance from the 08/2030UTC filament later in the UTC day of 12 February. Neither is expected to be particularly impactful, and Quiet conditions smay persist throughout, should both miss.

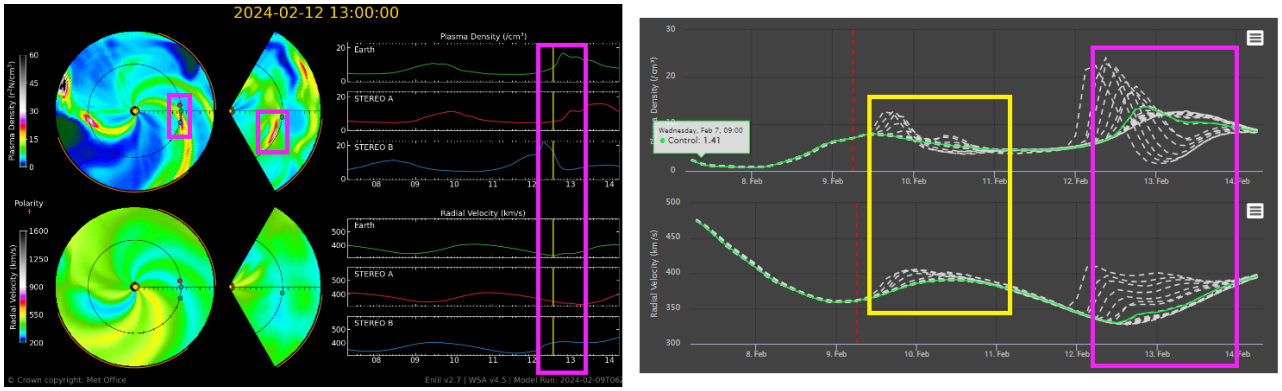
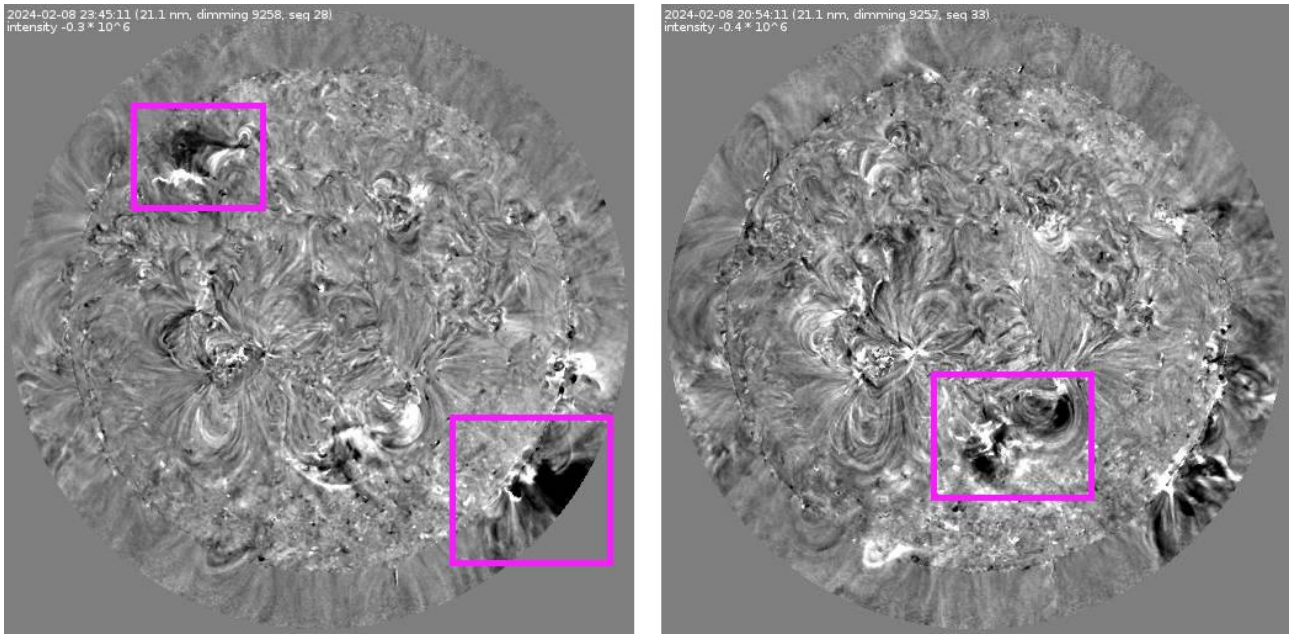


Figure 3: SIDC ROB-processed coronal dimmings in AIA211 difference imagery, showing two front-sided filament eruptions in the period and a southwest limb CME. In terms of arising CMEs,the northeast event could not be found on coronagraphs; the southwest is a probable miss but with modelling ongoing; and the third central one now features as a glance after 12/1200UTC.



Radio Blackouts - X-Ray Flares:

The balance of front-sided regions has been in slight decline in recent hours, perhaps reflected in a plateau in Penticton 10.7cm flux since midweek UTC. The risks of flare activity are now dominated by AR3576 near centre-disc with the passing of Ex-AR3575, although the latter does still factor into the probabilities for day one due to the possibility it throws emissive ejecta high into the corona, as seen in the past 24 hours.

The daily risk of significant flares shows an initial step-wise decrease in light of the above, however M-class flares are still considered Likely from AR3576, with a Slight Chance of X-class. The returning Carrington locations for several past regions are due over the eastern solar horizon in the period - the flux emanating from one of these is now visible in AIA171 over the southeastern solar horizon, however any contribution from these regions will be assessed as

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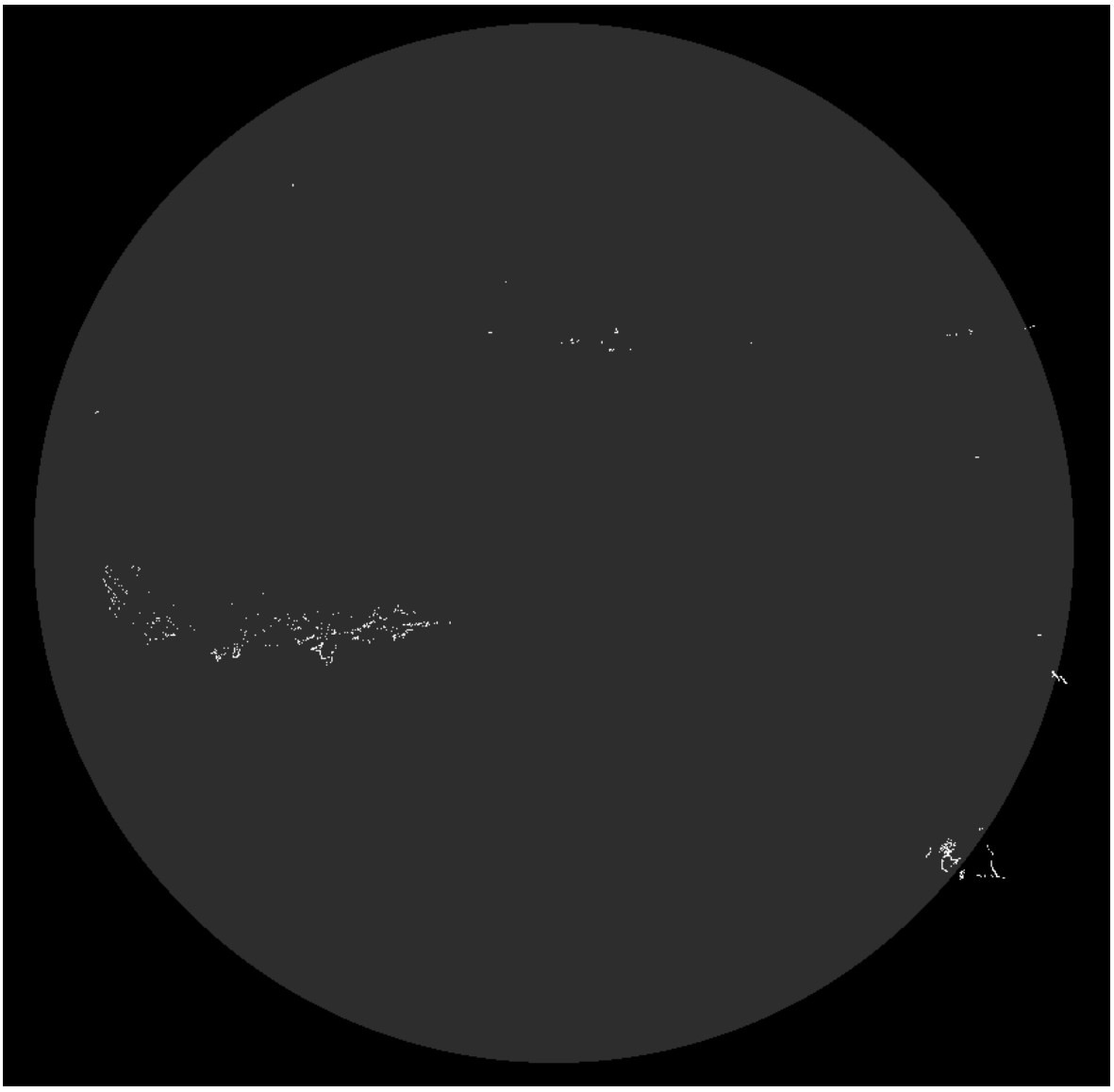
and when they appear over the eastern solar horizon.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**R1-R2 M Class**	Yes	70	60	60	60
Very Active	**R3 to R5 X Class**	No	20	15	15	15

Figure 3: SIDC ROB flare locations of C-class and above recorded by PROBA2. AR3576 can be seen to be dominant, and this is likely to become increasingly the case now Ex-Ar3575 has left the lower right of the disc. Any oncoming regions in the east are awaited, with no flare evidence for significant presences here as of yet.



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Solar Radiation Storms - (High Energy Protons):

GOES18 high energy (greater than 10MeV) proton flux is currently at Background levels. The high energy proton flux has the potential to rise in response to any significant flares, most likely from Ex-AR3575 or AR3576, with significant flares from these regions giving a chance of exceeding the S1/Minor Radiation Storm level.

Although Ex-AR3575's contribution to this risk is now in decline, this is likely to be compensated for by AR3576 as the latter transits into the western solar hemisphere, leading to a steady Slight Chance of S1 on all days of the period.

Radiation Storms	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ S1**	No	20	20	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES16 is expected continue at mainly Normal Background levels, given the expected absence of significant fast wind streams and glancing incidence of any CME activity.

The associated 24-hour electron fluence is expected to remain well below the Active (1e8 integrated flux) threshold, as suggested by MOSWOC REFM, although the current forecast period is likely to move away from a predictable coronal hole fast/slow pattern and more towards a threat of CMEs given AR3576's position on the disc, rendering REFM less usable.

GEO Electron Environment	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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